

# PLANT PROTECTION OVERSEAS REVIEW

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# PLANT PROTECTION OVERSEAS REVIEW

A PERIODICAL SURVEY OF NEW  
DEVELOPMENTS IN THE CONTROL  
OF PESTS, DISEASES AND WEEDS



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**ERRATA. "Plant Protection Overseas Review" Vol. 4, No. 2.**

On page 64, lines 7 and 8 of the abstract entitled "Maize Stalk Borer", for "21.2-lb. per acre" read "5-lb. per acre".

On page 68, in the abstract entitled "Argentine Ant Attacking Trellised Vines", summarising an article by H. J. R. Dürr in "Farming in South Africa", Vol. 28, No. 323, 1953, comparison was wrongly implied between the persistence of 0.25% dieldrin and other chemical materials used in three distinct experiments. Dieldrin was only employed in Experiment 2, which extended for one week. In common with 1% DDT, 0.25% lindane and 2% chlordane, 0.25% dieldrin gave effective control of argentine ant over this short period, but no test of persistence of dieldrin beyond this duration is reported by the author.

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## EDITORIAL

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ARTICLES in this number of the *Plant Protection Overseas Review* deal with a variety of subjects of world wide interest and importance in the field of crop protection. In an article by Dr. G. Watts Padwick, who has had years of experience with and is an authority on the problems concerning the cultivation and diseases of rice in India, the author discusses the use of seed dressings against diseases of this vitally important food crop.

In spite of the possibility of eliminating or suppressing some crop pests by biological means and cultural methods, and the dangers attendant on the indiscriminate use of chemicals in crop protection, there are still many pests which can be successfully combated only by the use of chemicals. Dr. E. Holmes, Head of the Technical Department of Plant Protection Ltd., throws a great deal of light on this question in an article reprinted from *Chemistry & Industry* by kind permission of the Editor of that journal, and stresses the importance of the intelligent use of chemicals in the protection of crops from their enemies.

An article by Mr. Brian Thompson of Fernhurst Research Station, who was attached to the Desert Locust Survey for twelve months, describes the campaign methods developed by this organisation against the depredations of the Desert Locust and some of the problems which are being tackled by them.

We welcome also an article on recent developments in the use of chemicals for the suppression of weeds in the sugar-cane fields of Mauritius. This contribution should contain information of interest and value to sugar-cane cultivators in other parts of the world and forms a useful addition to the series of articles on the treatment of weeds in various crops in different parts of the world.

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# SEED DRESSINGS IN THE CONTROL OF DISEASES OF RICE

by G. WATTS PADWICK, D.Sc., Ph.D.

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LIKE all cereals, rice suffers from a number of diseases, though not all are of economic significance. Most of them are caused by fungi, and noteworthy amongst these are "blast", "brown spot" and "foot rot" or "bakanae" disease. An important virus disease occurring in Japan is known as "stunt" or "dwarf" disease. Bacteria cause several troubles but they are of little economic importance. Nematodes or eelworms can cause two serious diseases, one being "ufra" or "dak pora", which is restricted to the Ganges-Bramaputra rice region, and the other "white tip", which has spread to the U.S.A. from the Far East.

The object of this note is to review some of the more important rice diseases with special reference to their control by the use of seed dressings.

## **Blast**

One of the most widespread and serious diseases of rice is blast and from time to time claims have been made that it is controllable by seed dressings.

Blast is caused by a fungus, *Piricularia oryzae* Cav., and is found in all countries where rice is an important crop. The fungus was described only as recently as 1891 although a closely related fungus of the same genus had been described 10 years earlier and probably the disease had been present in Italy almost from the earliest times of rice cultivation. The fungus is an imperfect one (having no sexual stage) with hyaline pear-shaped spores, which, though delicate, will survive for some months under dry conditions.

Blast appears first in the form of translucent spots on leaves of seedlings. The spots expand rapidly and on older leaves may attain a length of 3 cm. and a breadth of 1 cm. Though the spots are bluish when small, at a later stage they have pale green or dull greyish green centres with an outer rim of dark brown. Finally the centre may become grey or almost straw coloured (Plate I) (*facing page 86*).

The rachis or flowering stalk and even the rachillae on which the individual flowers are borne, as well as the glumes, may become blackened and rotten. In severe attacks, when this type of infection occurs, the entire panicle may be whitened or blasted, and it is at this stage that the greatest losses occur.

From the point of view of controlling the disease, the life history of the fungus is important. Only rarely is the disease seed-borne. It would appear that in most cases infection occurs from wild grasses which grow in the rice fields or along the "bunds". For example, in South India, as Thomas and Krishnaswamy (1) state, the grass *Panicum repens*, abundant in the neighbourhood of rice crops, is commonly infected. The fungus can spread, too, from one leaf to another, causing "self-infection" of the plant; from one plant to another; and between adjacent crops. Just how far the delicate spores can blow in the wind and retain their viability so as to be able to infect other crops, is uncertain. The possible cycle of infection is illustrated diagrammatically in Fig. 1.

Important progress has been made in the selection and breeding of rice varieties resistant to blast. Many resistant varieties have been found; for instance, in Japan by Nisikado (2), Nakatomi (3), Suzuki (4, 5), Abe (6), Kawamura (7); in India by Sundararaman (8, 9), Thomas (10, 11), Ramiah and Ramaswami (12); and in America by Cralley and Adair (13). However, this answer to the problem, ideal though it may appear to be, presents difficulties. A resistant variety may be suitable for only limited geographical distribution, and, as shown by Thomas and Krishnaswamy (1) and Krishnaswamy *et al.* (14), apparent resistance may break down under certain conditions, such as alteration of the date of sowing.

Since blast is neither seed-borne nor soil-borne, seed protectants cannot be expected to be effective. Two factors, it is known, influence the susceptibility of the plants. Abnormally dry seed beds and excessive application of nitrogenous fertilizers predispose plants to disease; therefore both these conditions must be avoided. However, the evidence suggests that the chief effect of these conditions is to enhance susceptibility only; they do not render a highly resistant variety susceptible. Direct protection can be provided by the use of fungicidal sprays, which in Japan are considered a practical proposition, at least for the seedlings. It is not, however, very easy to spray fields of transplanted paddy. Copper sprays are used in the nurseries and organo-mercurials are reported to be successfully applied in Japan. There is scope for research on the machinery for application, on formulations for adequately wetting the leaves, on frequency of spraying, and on the economics of the method. It is desirable, too, to learn more than we know at present about the distance which the fungus can spread by wind and still retain its viability; that is to say, to determine to what extent a crop will be liable to become rapidly reinfested from neighbouring crops.

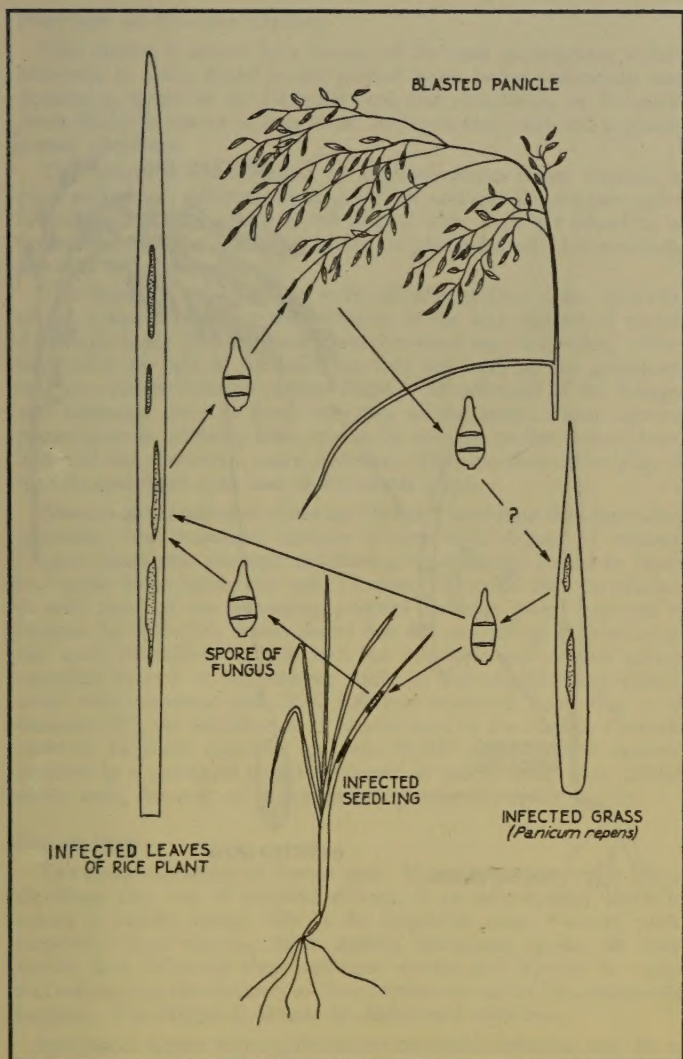


FIG. I

SOURCE OF INFECTION OF RICE WITH  
BLAST (*Piricularia oryzae*) IN SOUTH INDIA

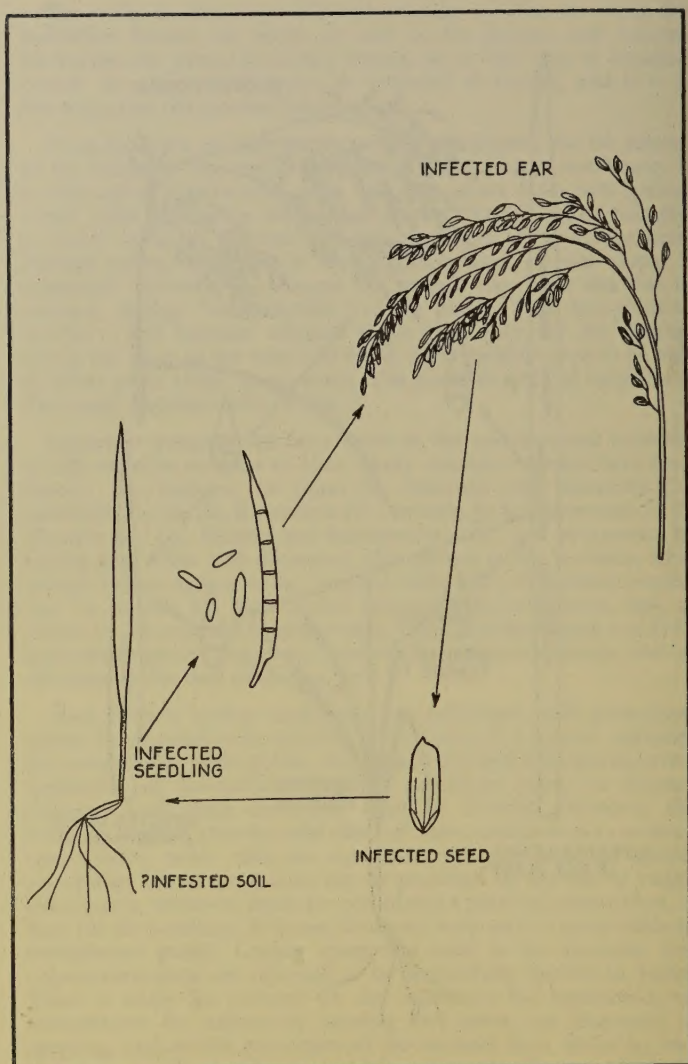


FIG. 2  
CYCLE OF INFECTION OF RICE WITH  
"BAKANAE" DISEASE (*Gibberella fujikuroi*)

## Foot Rot or bakanae disease

This disease is caused by a fungus of the class ascomycetes which, however, is rarely found in the perfect stage, being commonly seen producing spores of the *Fusarium* type and identifiable as *F. moniliforme* Sheld. It causes serious losses in Japan and India and probably occurs elsewhere.

The disease is characterised by a phenomenon rather unusual in plant pathology. Affected plants grow tall and spindly, are pale green in colour, and fail to tiller in the normal way. They are found to be brown and rotten at the base. Usually the plants die early but occasionally they will reach maturity.

The disease is very different in its life history from blast. Infection of the grains takes place somewhat as in the scab disease of wheat. Although badly infected grains are browned and shrivelled, others may show no sign of the infection they are carrying but germinate and give rise to infected plants. There is no infection of the foliage, and although there is local infection of the grains from infected plants there is probably little spread by wind as in the case of blast. The soil can, however, carry infection. The infection cycle (Fig. 2) may be compared with that of *Piricularia oryzae*.

Because initial infection of the seed is more important than secondary infection, seed treatment ensures a very high degree of control. Organo-mercurials are used and have given excellent results in Japan and India. Even before the war, Thomas (15) stated that the practice of seed dressing was becoming popular amongst paddy growers in Madras. In 1948 (16), it was stated that for one village in Madras all the seed (40,000-lb) (18160 kg.) for one year was treated giving complete control of the disease, whilst in the neighbouring village, sown with untreated seed, 20% infection occurred. According to an estimate (17), the distribution of treated seed by the Madras Government in sufficient quantity to treat 40,000 acres (16200 hectares) resulted in a saving of paddy estimated at nearly 2,300 tons (2336.8 metric tons), the cost of treatment being only Rs. 2,400 (£170).

## Brown Spot

The causal organism of brown spot, *Helminthosporium oryzae* Breda de Haan, like that of bakanae disease, is an ascomycete, which in nature is usually found only in the imperfect stage, forming comparatively large septate, thick walled, olivaceous spores, on thick walled dark coloured conidiophores—spores and hyphae as tough and resistant to the elements as their appearance under the microscope suggests. The fungus is almost co-distributed with rice.

Symptoms appear from germination onwards. Infection may be so severe that germination is inhibited or the germinated seedling is blackened and rotted before it can emerge from the soil. If, however, it survives, the coleoptile will have circular to oval brown spots or even long streaks. The first leaves may similarly have spots or streaks.

Later on, minute dots or circular eye-shaped or oval spots, measuring up to  $1\frac{1}{2}$  cm. long and as much as 3 mm. broad, appear on the leaves. The smaller spots are dark or purplish brown; older and larger ones may have a pale yellow, dirty white, brown or grey centre. With severe infection the plants have a dry and rusty appearance. The inflorescence too may be attacked, brown spots appearing on the surface of the glumes, whilst those more heavily infected may be coated with the dark brown or deep olivaceous brown mycelium and spores, which form a velvety mat on the shrivelled and empty glumes.

The loss resulting from this disease can be extensive, although reliable estimates are difficult to make. In some areas, such as parts of North East India, it appears to be endemic though varying in severity from year to year. Losses reach their greatest proportions when heavy secondary infection occurs and when the inflorescences are attacked. This happened in Bengal during the year 1942 and is considered to have been a major factor contributing to the Bengal Famine.

The undoubtedly great losses which the disease causes derive from the fact that the fungus combines some of the characteristics favourable to its survival and spread which are possessed by both the blast and the bakanae fungi. As in the case of the latter, the fungus is readily seed-borne, and from many important rice growing centres it is impossible to obtain seed free from infection. The spores are, however, produced on leaves and more especially on the glumes as in blast and are picked up and spread by the wind, possibly over great distances, to infect leaves and glumes of other rice plants. It has recently been shown in Bengal by Chattopadhyay (18) that a wild grass is infected in nature, though just how important this is in practice is uncertain. It is difficult to determine how far the spores blow but they can be found in the atmosphere in varying numbers throughout most of the year in Bengal. Other possible sources of infection are infested stubble or trash, and the soil. Fig. 3 illustrates the infection cycle of brown spot.

As in the case of blast, the seedlings are rendered more susceptible to brown spot infection if grown under excessively dry conditions. It has not, however, been demonstrated that excessive nitrogen exerts much influence. Low temperatures render the seedlings especially susceptible but infection can, and in all probability frequently does, take place under the moderately high temperatures prevalent at the time the seed is in the nursery bed. An example of infection of self-sown seedlings almost certainly arising from the seed-borne fungus is shown in Plate II (*facing page 87*), numerous volunteer plants having been found by the author to be so infected in Assam in 1953.

Varieties showing differing degrees of resistance have been found in the Philippines by Reyes (19), in Bengal by Ganguly (20), in Japan by Tochinnai and Sakamoto (21), and in Columbia by Bernal Correa (22), though other workers, for example Cralley (23) in America and Thomas (24) in South India, have had less success. The search for

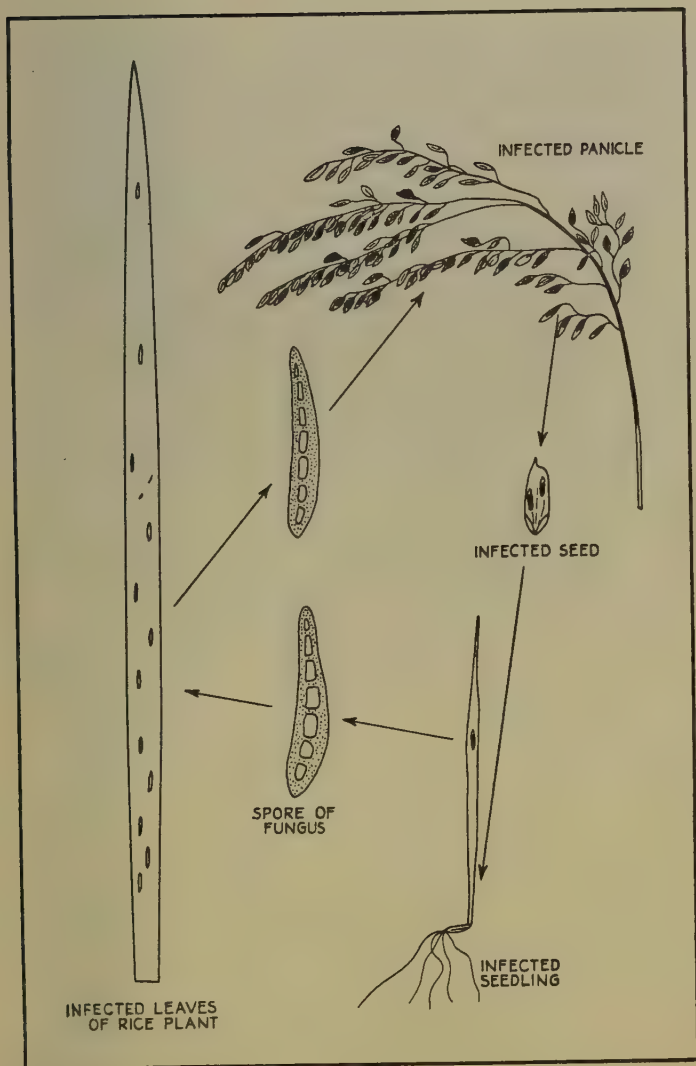


FIG. 3  
CYCLE OF INFECTION OF RICE WITH  
BROWN SPOT (*Helminthosporium oryzae*)

resistant varieties is now being intensified at certain rice breeding centres.

The seed-borne nature of this disease points to the use of a seed dressing, and organo-mercurial dressings have been found to give a good measure of control. What is not clear, however, is the extent to which secondary infection spreads in from adjacent untreated crops or from soil, stubble, volunteer seedlings, and wild grasses. This requires experimental work spread over several years and over a range of conditions. A number of experiments have been laid down by workers in India with a view to finding the most suitable type of dressing, the effect of dressings on emergence and seedling infection, the extent to which secondary infection masks early control, and the final effect on yield of grain and straw. Another desirable experiment is to obtain large blocks of at least a square mile in which all the rice is treated in order to test the effect of remoteness from untreated and infected seed upon the continued freedom from disease of the crop grown from seed which has been dressed.

In India today a drive is being made to encourage what is called the "Japanese method of rice cultivation". This involves the adoption of a number of practices which are recognised as good cultural methods, such as careful manipulation of water in the seed bed, transplanting in rows a small number of individually spaced plants to allow of inter-tillage, ample manuring and control of pests and diseases. The method involves the use of a much smaller number of plants per acre than is common practice in India and consequently a smaller number of plants in the nursery. If the method is to succeed, the germination must be assured and the seedlings for transplanting must be healthy. Seed treatment with organo-mercurials should give the best assurance of these two requirements and it is reasonable that it should be widely adopted.

### **Stackburn disease, seedling blight and leaf spot**

A disease which was long overlooked because of the comparative insignificance of the fungus causing it is known as stackburn disease. Associated with the fungus which causes it, namely *Trichoconis padwickii* Ganguly, are a seedling blight and a leaf spot.

The diseased condition can be found in the seed where the glumes show pale brown or faintly pink to reddish brown discoloured spots. If the disease has developed under very humid conditions, the kernels may be deformed or shrivelled and brittle and to a large extent replaced by the black sclerotia of the fungus.

Badly affected seeds will not germinate but those with a mild attack will develop into seedlings with black spots on the roots and brown to black patches or streaks on the coleoptile. Later on the leaves may be infected and the spots formed bear much resemblance to those of blast though not having the translucent appearance exhibited by the latter. The most serious aspect of this disease, which occurs in the



Plate I. Leaf infection of rice with blast (*Piricularia oryzae* Cav.)



Plate II. Seedling infection of rice with brown spot (*Helminthosporium oryzae* Breda de Haan.)

U.S.A. and which is widely distributed in India, is its effect on germination. Even seed which looks healthy may carry heavy infection. For instance, Padmanabhan (25) found that from 51% to 76% of seed in five different lots, which for all practical purposes appeared externally healthy, carried infection.

Hot water treatment will kill the fungus without severe injury to the seed. This is, however, a troublesome process and we need experimental work on the use of fungicidal seed dressings.

### White Tip Disease

This disease is caused by a nematode or eelworm, *Aphelenchoides oryzae* Yokoo, and occurs in Japan and the U.S.A. In some respects the symptoms resemble those caused by a mild attack of "ufra" disease, which occurs in Bengal and causes great damage. However, unlike that disease, which is carried over in the soil, the eelworms causing white tip are carried on the seed. Nematodes, which are viable and capable of causing the disease, have been found beneath the glumes of rice seed as long as eight months after the rice has been harvested. In practice in the U.S.A. it has been found possible to reduce infection in the field by early planting and by the growing of certain resistant varieties, for example Arkansas Fortuna, Nira 43, Blue Bonnet, Century 231 and Century 52. Control of the disease has been obtained by fumigating the seed with methyl bromide, but unfortunately if the moisture content is high the germination of the seed is liable to be reduced, and the concentration of the fumigant must, therefore, be adjusted to the moisture content of the seed. An alternative method is the treatment of the seed with hot water, but again there is a definite risk of seed injury. Some promise has been shown by dressing the seed with phosphate insecticide dusts.

Not all the diseases, of course, can be controlled even partially by seed dressings. Mention has already been made of blast, where seed treatment with any existing dressings is not likely to be successful. Reference has also been made to the nematode disease, "ufra," which, being carried in the soil, cannot be effectively controlled by seed treatment. Some of the important fungus diseases, such as narrow brown leaf spot caused by *Cercospora oryzae* Miyake, several important stem rot diseases, and leaf smut are for the same reason not controllable in this way. Even black smut or bunt cannot be influenced by seed dressings as it is not seed-borne. Naturally the virus diseases, such as stunt or dwarf disease, are not affected by fungicides. However, the instances illustrated above indicate how seed dressings may play an important part in the control of some diseases. Apart from these fairly well demonstrated instances, there is a general measure of protection probably given against a number of fungi. For example, *Curvularia lunata* (Walker) Boedijn, which is common enough on rice seed in some countries, can under certain conditions cause seedling blight and a leaf disease not unlike brown spot.

Several other fungi are common on the seed though of undetermined importance. Yet others occur in the soil and are believed to cause seed rot and damping off, against which seed dressings may be expected to give a degree of protection. There can be little doubt that the benefits of seed dressings in preventing seedling infection and establishing a good stand of healthy seedlings can play a valuable part in any programme for improvement of the rice crop.

## REFERENCES

- (1) Thomas, K. M. & Krishnaswamy, C. S. (1948). The Control of the Chief Diseases of Rice as a means of increasing production. *Madras Agric. J.*, XXXIV—XXXV, Nov. 1947—Feb. 1948.
- (2) Nisikado, Y. (1927). Studies on the rice blast disease. *Jap. J. Bot.*, iii, pp. 239-244.
- (3) Nakatomi, S. (1927). On the variability and inheritance of the resistance of the rice plants against the rice blast disease. *Jap. J. Genet.*, iv, pp. 31-38. [Japanese. Abs. in *Jap. J. Bot.*, iii, pp. (101)—(102), 1927].
- (4) Suzuki, H. (1934). Studies on the influence of some environmental factors on the susceptibility of the rice plant to blast and *Helminthosporium* diseases, and on the anatomical characters of the plant. I. Influence of differences in soil moisture. *J. Coll. Agric.*, Tokyo, xiii, pp. 45-108, pls. viii and ix.
- (5) ——— (1937). Studies on the relations between the anatomical characters of the rice plant and its susceptibility to blast disease. *J. Coll. Agric.*, Tokyo, xiv, pp. 181-264.
- (6) Abe, T. (1936). Comparison of pathogenicity in different culture strains of *Piricularia oryzae* and varietal susceptibility of the rice plant to the blast disease. *Ann. phytopath. Soc. Japan*, vi, (1), pp. 15-26. (Japanese, with English summary).
- (7) Kawamura, E. (1940). Reaction of certain species of the genus *Oryza* to the infection of *Piricularia oryzae*. *Bult. sci. Fak. terk. Kyusu Univ.*, ix, pp. 157-166. (Japanese, with English summary. Abs. in *R.A.M.*, xxi, p. 96, 1942).
- (8) Sundararaman, S. (1927). Administration Report of the Government Mycologist, Coimbatore, for 1926-7. (Abs. in *R.A.M.*, viii, p. 17, 1929).
- (9) ——— (1929). Administration Report of the Government Mycologist, Coimbatore, for 1928-9. —in *Rep. Dep. Agric.*, Madras, 1928-9.
- (10) Thomas, K.M. (1930). Some aspects of the control of blast disease of paddy. *Madras agric. J.*, xviii, pp. 596-606.
- (11) ——— (1938). Detailed Administration Report of the Government Mycologist, Madras, for the year 1937-8.
- (12) Ramiah, K. & Ramaswami, K. (1936). Breeding for resistance to *Piricularia oryzae* in rice (*O. sativa*). *Proc. Indian Acad. Sci.*, iii, pp. 450-458.
- (13) Cralley, E. M. & Adair, C. R. (1942). Rice blast in Arkansas. *Plant Dis. Repr.*, xxvi, pp. 149-150.
- (14) Krishnaswamy, C. S., Govindaswamy, C. V., Adyantaya, N. R., & Rangaswamy, G. (1952). Studies on varietal resistance of rice to the blast disease (*Piricularia oryzae* Cav.). Reprinted from *Proc. Sci. Workers' Conf.*, Madras Agric. Dep. Pub., 12 pp.
- (15) Thomas, K. M. (1938). Detailed Administrative Report of the Government Mycologist for the year 1937-38, in *Admin. Repts. Agric. Chem., Entom., and Mycol.*, Madras, 1937-38, pp. 40-60.
- (16) Anonymous (1948). Foot-rot of Rice in Madras. *Indian Fmg.*, IX, pp. 418-419.
- (17) Rao, Govinda G. (1951). Control of plant diseases in the Northern Region of the Madras State in the year 1949-50. *Plant Protection Bull.* Vol. 3, No. 1, pp. 21-22.

- (18) Chattopadhyay, S. B., & Chakraborti, N. K. (1953). Occurrence in Nature of an Alternative Host (*Leersia hexandra* Sw.) of *Helminthosporium oryzae* Breda de Haan. *Nature*, 172, p. 550.
- (19) Reyes, G. M. (1939). Rice diseases and methods of control. *Philipp. J. Agric.*, x, pp. 419-436.
- (20) Ganguly, D. (1946). *Helminthosporium* disease of paddy in Bengal. *Science & Culture*, xii, pp. 220-223.
- (21) Tochinal, Y., & Sakamoto, M. (1937). Studies on the physiologic specialization in *Ophiobolus miyabeanus* Ito et Kuribayashi. *J. Fac. Agric., Hokkaido Univ.*, xli, pp. 1-96.
- (22) Bernal Correa, A. (1940). Las enfermedades del Arroz y su importancia económica en el Valle del Cauca. *Rev. Fac. nac. Agron. Colombia*, iii., pp. 820-850.
- (23) Cralley, E. M. (1932). *Plant Pathology*. Fortyfourth Ann. Rept. Ark. agric. Exp. Sta. for the year ending June 30th, 1932 (Bull. 280), pp. 54-58.
- (24) Thomas, K. M. (1941). Detailed Administration Report of the Government Mycologist, Madras, for the year 1940-1, 22 pp.
- (25) Padmanabhan, S. Y. (1949). Occurrence of fungi inside rice kernels. *Curr. Sci.*, 18, pp. 442-443.



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# INSECT POPULATION BALANCE AND CHEMICAL CONTROL OF PESTS

An Agricultural Chemist's Attitude Towards Insecticides

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*(Paper read before a joint meeting of the Agriculture Group  
(Crop Protection Panel) of the Society of Chemical Industry and  
the Association of Applied Biologists on November 12, 1952).*

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ALTHOUGH I happen to be connected with a chemical manufacturing organisation, may I repeat what I have said from many platforms: chemicals are no substitute for good husbandry. The farmer must cultivate his crops, by traditional methods, the best way he knows and then, if insect pests, fungus diseases and weeds look like getting out of hand, he must use chemicals as adjuncts to good husbandry.

Scientists dealing with crop protection are frequently accused of upsetting the balance of nature. This may be so, occasionally, but modern farming practices such as the growing of large tracts under monoculture, the continued growing of cereals or potatoes on the same areas and so on have already upset the old balance of nature. The intelligent use of crop protection chemicals is at least one good way of restoring that balance.

As to the specific subjects for discussion today, the attitude of many Americans towards them is that, having found a new insect pest and having established that a particular chemical will control it, then that chemical should be used widespread, irrespective of side effects. If the treatment subsequently induces attacks by other insects then the American is prepared to treat this as a separate problem and to cross that bridge when he comes to it. The opposing attitude is that every possible side effect should be investigated before any new insecticide is released to growers. The correct view is surely somewhere between these two extremes. Some of the troubles experienced in this field in America are put down to premature publication by scientific workers in that country. The opposite view has been expressed as : " When you're half way through the job and have

struck the snags, that's the time to publish. So many folk want to climb on the band wagon that some of them at least will help you out of your difficulties ! ”

On the second attitude, it has been my experience in this country that the so-called pure research worker always has another half-dozen related problems to clear up and wants just one more year before he is sure of his ground. Equally, however, it has been my experience that if, at this stage, the product concerned is taken on to the farm, and preferably handled by an intelligent farmer, that experience very soon indicates which of the research worker's half-dozen problems need further study before the product is generally released.

Three types of world insect problem are :

1. The case, such as that of the fruit grower, where the incidence of pests reduces quality and therefore value primarily, and where total weight of crops is probably secondary.
2. The case of large scale arable crops, particularly those of only marginal profitability, where the return from the use of insecticides is very much smaller.
3. National problems, such as the control of locusts, where comparatively little is done or can be done by individual growers.

### **Insect build-up due to insecticides**

It is probably in the first category—the case of the fruit grower—that the problems are so many and complicated as to have given rise to difficulties with parasites and predators, and demands for the cessation of use of insecticides. On the other hand, the great rise in population of the red-banded leaf-roller, *Argyrotaenia velutinana*, in 1946-1949 in the apple orchards of eastern North America was probably owing to the substitution of DDT for lead arsenate in the spray programme. DDT, while no more effective against the leaf-roller than lead arsenate, is considerably more effective against its parasites and predators (1). This is a case of fashion over-ruling common sense and the remedy is obvious.

Again, the increase in population of the oriental fruit moth, *Grapholitha molesta*, in American orchards can also be attributed to the use of DDT in the spray programme. Parasitism of the moth larvae in Ohio dropped from 58% in 1946 to 23% in 1947 ; residual deposits of DDT have little effect on the larvae of this fruit moth, but are lethal to the braconid parasite, *Macrocentrus ancylivorus*. On the other hand, the application of BHC against the moth has resulted in an increase of parasitism of the larvae to 45% as against 27% in the untreated plots ; in this case much of the residual effect of the insecticide is lost by the time the parasites emerge (2). Again, a slightly less impetuous approach to the problem would have been wiser.

Incidentally, although it has been established in this country that the incidence of the fruit tree red spider can be, and has been increased by the use of DDT under some conditions, my colleague, Mr. Stapley, who has made a special study of the subject, knows of no single authenticated case of red spider build-up being caused by applications of BHC.

Further instances in this sense could be given; other speakers today doubtless will, but the general point made here is not that we should stop using insecticides but that we should use them a little more intelligently.

### Biological methods of control

Some of those who decry the use of insecticides claim that biological control is *the* method of the future, for when and where a parasite or predator can be successfully established, and does its job reasonably completely, it is obviously the cheapest and best method for the grower.

For example, *Trichogramma evanescens* is used extensively in the control of the sugar cane borer, *Diatraea saccharalis*. The parasite has shown considerable promise in reducing the borer infestations in Louisiana.

Similarly, the coccinellid, *Rodolia cardinalis*, was artificially introduced into California from Australia, and was successful in controlling outbreaks of the cottony-cushion scale, *Icerya purchasi*, although the parasite is more susceptible than its host to applications of insecticides.

The giant toad, *Bufo marinus*, a native of Central America, was artificially introduced into several islands of the West Indies group, Australia, the Philippines and Louisiana to control sugar cane white grubs.

*Aphelinus mali*, a parasite of the woolly aphid pest of apple, *Eriosoma lanigerum*, native of the United States, has been established artificially in Great Britain and Europe, Japan, Australia, New Zealand, Chile, Argentina, Uruguay, and South Africa. The parasite is unable to attack aphids below ground but is very valuable in destroying the aerial forms. In those parts of the world where aerial forms are dominant, control has been excellent, but wet and cold conditions are detrimental to the parasite and the establishment of colonies in some countries has been difficult.

Apart, however, from these few examples and of course the classic work in Fiji on the coconut moth, the regrettable fact is that such methods prove successful so infrequently that they make little impression on world insect problems in agriculture.

### Cultural control methods

In speaking of cultural control methods it is clear that the basis of indirect control of insect pests in farm crops is the rotation; a continual change in crop makes it difficult for pests which do not spread easily to survive. The increase in potato and sugar beet eelworm is a result of the repeated cropping of potatoes and sugar beet;

the increase in root fly pests to the intensified cultivation of cruciferous crops.

It is frequently possible to sow a crop early or late enough to escape the peak emergence of a pest. A good example of this is seen in connection with frit fly, which attacks oats more severely if they are sown later than mid-March. Wheat sown in October will often withstand attacks of wireworm, wheat shoot beetle, and wheat bulb fly, whereas wheat sown in November may fail entirely owing to pest attacks.

Wireworms in grassland are little affected by July ploughing and fallowing, but are profoundly affected by ploughing earlier in the year and subjecting the land to a full summer fallow. Ryegrass and clover leys ploughed in September are liable to contain the third generation larvae of the frit fly which, after ploughing, will migrate to wheat. Earlier ploughing will prevent eggs being laid in the field.

Obtaining a balanced plant food supply by the judicious application of organic and inorganic manures will promote heavy growth and the ability to resist insect attacks. Quick-acting fertilizers will stimulate growth during a critical period of lowered vitality arising from pest attack, *e.g.* of flea beetle. However, excessive amounts often produce lush, sappy growth which attract aphids; luxuriant growth may mask the foliar symptoms of eelworm attack (*e.g.* chrysanthemum eelworm).

Many insects overwinter at the base of hedges or in piles of rubbish. Weeds provide alternative plant food and enable insects to survive in cultivated land where they might otherwise tend to die out. Pests of cereals are nearly always able to live on a grass weed host; flea beetles are always well provided for by charlock and shepherd's purse, two of the commonest weeds of arable land.

The farmer must use these methods wherever appropriate.

But, having admitted quite freely that chemical insecticides have sometimes done harm, and that biological and cultural methods certainly have their place in the scheme of things, the fact remains that growers everywhere still have insect problems and must do something more about them.

Although there is no doubt that in the future a greater understanding and therefore avoidance of side effects of the use of insecticides will come, and there will probably be greater use of biological and related methods of control, to look at the problem realistically today it must be recognized that growers will insist on using insecticides.

To take the case of the grower in the first category mentioned earlier, it is against human nature to expect a grower not to insist on getting a new product when he knows it will solve one of his major problems and therefore give him a greater cash return. It is even more against human nature to expect a manufacturer to refuse to

provide that chemical if he knows it will do the grower's job, and there are no obvious deleterious side effects.

Several speakers have mentioned the very high cost of sprays. But surely the farmer only uses them because they pay him.

### **Problems of lower value crops**

Most of the considerations dealt with so far concern high value crops, particularly fruit. They have received attention for much longer, simply because they could stand higher costs per acre. With the advent of the newer, more powerful insecticides such as DDT and BHC, however, and the development of new techniques of application, crops showing much lower returns per acre have come into the picture very much more.

For example, DDT and BHC are now used much more widely than the derris previously used for the control of flea beetle, and no deleterious side effects are known. When crude BHC was first found to be so effective against wireworms, however, its use was developed too enthusiastically, especially in America. Tainting of potatoes and other crops occurred and new approaches to the problem had to be tried. Adequate and intelligent experimental work soon showed that the use of the relatively pure gamma-BHC minimized the tainting trouble, and the further step of incorporating gamma-BHC in the conventional organo-mercury seed dressings very largely solved the problem—at least so far as concerns cereals. There is no record of tainting of cereals following such applications nor, what is significant, of subsequent potato crops.

What is perhaps even more important from the long term point of view is that there is no evidence that soil applications of this kind have any deleterious effects on soil fauna and flora.

### **National problems**

Regarding insect pests which may be regarded as national problems, first among these is obviously the locust. Arsenicals have given place almost exclusively to BHC as the basis of poison baits in control campaigns, and the baiting technique is augmented in special circumstances by land and air application of sprays based on DNOC, aldrin or gamma-BHC.

A point to be made here is that, as the predominant portion of this work is done on deserts and on land sparsely inhabited by wild animals or animals belonging to nomad tribes, the possible damage that chemicals could do is minute. Further, even if a little damage is occasionally done it is absolutely microscopic in relation to the tremendous benefits from the removal of the locust menace. The same considerations apply to the control of malaria-carrying mosquitoes, though here we are concerned only indirectly with agriculture.

It is concluded from the foregoing that, with a world clamouring for food and yet more food, the primary producer must rely, at least

for many years to come, on chemical insecticides to prevent substantial crop losses.

### **Dangerous chemicals**

As regards the problem of dangerous chemicals, as a result of the deliberations of the Zuckerman Working Party, emphasis is being placed on the desirability of finding insecticides and related products that are less poisonous to mammals than, for example, the organophosphorus insecticides. A tremendous amount of work is going on—in Britain, the U.S., Germany, and elsewhere—particularly within the large chemical firms, to uncover new products in this field. But it should be emphasized that we need to know a great deal more about the relationship between chemical constitution and insecticidal activity on the one hand, and toxicity to mammals on the other. Until we do, it is quite impossible deliberately to look for non-poisonous insecticides. The only practical procedure at present, and the procedure followed by most of the firms mentioned, is to screen large numbers of new chemicals for insecticidal activity and, as soon as any look of interest, to check them for mammalian toxicity.

For example, our parent company, I.C.I., opened a new testing station at Hawthorndale in 1935. In the first ten years they screened some 14,000 new chemicals there. Less than 0.1% of these showed enough promise to justify further work. Obviously it was very much simpler and cheaper first to test these as insecticides, as weedkillers, and so on, and then to check the mammalian toxicity of the few promising candidates. Such work as this has in fact in recent years produced the relatively safe insecticides DDT and BHC, the fungicide TMT (thiram), and the selective weedkillers 2,4-D and MCPA.

Many people have asked, in view of these successes, why do firms persist in working among the so-called dangerous chemicals? The phosphorus insecticides can be taken as an example in answering this question. It is true that at present the most successful phosphorus insecticides are very dangerous. It is, however, also true that a very large number of phosphorus chemicals are not dangerous; further it has already been established that the mode of action of at least some phosphorus compounds is quite different in insects and in the higher animals. In particular some phosphorus compounds have been shown in the laboratory to be highly insecticidal and yet of very low toxicity to mammals. Unfortunately, while these point the way to further research, they are not yet practical insecticides.

Finally, the answer to a number of speakers earlier in the Conference is at least partly in the hands of the research stations and universities. If they did less work in looking for new chemicals in this field—and they can never hope to compete with the bigger chemical manufacturers—and did more work on biological fundamentals, then the position as outlined will be brought more quickly into proper balance.

Almost certainly the most valuable work that could be done by official research stations would be to intensify such work as Dr. Wigglesworth is doing at Cambridge on insect physiology, and Dr. Massee is doing on fundamental problems at East Malling. This would provide a wider background for the chemists to plan their synthetic work more intelligently.

There has been a very considerable change in the relationship between official institutes and chemical companies in the last twenty years ; an even greater understanding by each of the other's problems will assist everyone, and more particularly the agricultural producer.

#### REFERENCES

- (1) Gould & Hamstead, J. econ. Ent., 1948, **41**, 887-890.
- (2) Prings & Weaver, *ibid.*, 1948, **41**, 566-569.



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# TRENDS IN DESERT LOCUST CONTROL

by BRIAN THOMPSON

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EVERYONE has at some time or other heard of the locust and its extraordinary capacity for destruction to vegetation but it is not generally known how large and extremely active are the organisations set up to combat this ever-present menace to the existence of virtually millions of people.

As the writer has recently returned from a twelve-month period of secondment to Desert Locust Survey it is thought that readers may be interested in a short review of the work and some of the problems of this organisation.

## ANTI-LOCUST RESEARCH CENTRE

This body, set up in 1929, is now financed by funds from British Colonies and Dominions and a grant from the Colonial Research Fund, and is housed in the Natural History section of the British Museum in London. The Director of the organisation is Dr. B. P. Uvarov, C.M.G., F.R.S., who is a world-wide authority on *Acrididae*.

When this body first came into being, a scheme for collecting current information on locust movement and breeding in the Middle East and Africa was started and scientists were sent into the field to study the problem on the spot. Between 1930 and 1939 intensive efforts were made to collect information. Whole seasons were spent studying locusts and their habits. Encouraging the natives to report on any locust movements they had witnessed and enlisting the support of civil administration in this work was also undertaken. From all this information received in London, charts were made of the incidence of locust swarms and it was seen that most of the outbreaks could be traced to a few particular areas where conditions existed allowing the locusts to breed undisturbed. A good example of this type of area is the Red Sea coast of Saudi Arabia and the Yemen.

One of the main duties of the Research Centre today is to keep abreast of all developments and movements of locust swarms and, by comparing these with past records, to forecast what areas are likely to be invaded and issue warnings to the countries concerned so that preparations for the campaign can be started well in advance of the actual invasion. Investigations on locust biology and methods of control are also conducted by the Centre.

## DESERT LOCUST SURVEY AND CONTROL

Desert Locust Survey, with headquarters in Nairobi, was formed in October 1948. The object and aims of this organisation are :—

1. To develop preventive control measures of the Desert Locust in co-operation with other interested organisations.
2. To investigate and keep under observation those suspected areas not adequately covered by other organisations.
3. To carry out research into the factors influencing the start, extension and termination of a plague.
4. To develop control techniques.
5. To give warning of threatening plagues.
6. To carry out control measures at the time of an outbreak until it is suppressed or an emergency control organisation is established.
7. To provide key personnel for the emergency organisation when needed.

It will be agreed that the above aims are not inconsiderable. When, in the early part of 1950, it became known that large swarms were widely distributed, extending to areas as far apart as Eritrea and Pakistan, and it was apparent that control measures could not be organised on a large enough scale to wipe them all out, it was decided to form a control organisation to carry out this work, leaving the original Survey as free as possible to carry on research and advise on the technical aspects of the imminent campaign.

The position, then, in October 1950 was that two closely linked organisations had been formed ; 1. Desert Locust Survey, responsible for research work and technical advice and assistance to 2. Desert Locust Control, whose job it would be to carry out to the best of their ability the control of the desert locust in each of the various territories in which they would operate.

The development and growth of the Control organisation continued until, by the end of 1952, one hundred and fifty-two officers were working with the organisation, which possessed two light aircraft and four hundred and seventy-five vehicles.

Desert Locust Control operates in a number of countries, namely Aden Protectorates, British East Africa, Somaliland Protectorate, Saudi-Arabia, Eritrea, Ethiopia, Kuwait, Yemen and the trucional States of Oman. Other countries like Egypt, Sudan, Pakistan, India, Iran, Iraq, Syria, Lebanon, Turkey and Jordan, run their own independent locust control units and it will be realised that a colossal area is now being covered in this never-ending fight to stamp out the locust scourge.

Not, however, until international co-operation has reached a much more advanced stage can there be any real hope of this one aim becoming a reality ; one country where breeding takes place by refusing to take an active part in these campaigns can readily undo the good work of several others.

## METHODS OF CONTROL

It was not until early in this century that poison baits were used for locust control. Prior to the use of these baits perhaps the most popular method of controlling locusts in nearly all countries was the use of ditches. This method was based on catching the marching bands in deep ditches with vertical walls where the trapped hoppers were either crushed or smothered to death by piling earth over them. This method was both slow and cumbersome and to attempt to clear large infested areas in this way was almost impossible and even with unlimited labour the costs became very high indeed.

The first poison baits to be used were usually mixtures of arsenates and wheaten bran. After preliminary field tests it was obvious that they were a powerful new method of control. Baits could be mixed at some central point and distributed by camel or truck to points where they were needed. One sack of bait properly distributed could be made to cover a large area and result in the destruction of innumerable hoppers.

Unfortunately, there were drawbacks to these methods. Great care had to be taken throughout all operations due to the toxic nature of the poison and it was also necessary to see that the bait was distributed lightly and evenly over the ground in order that camels, goats and other livestock were unable to pick up a lethal dose. This, using unskilled native labour, was by no means an easy task and numbers of animals did in fact die as a result of these locust control measures.

In 1944 'Gammexane' (the I.C.I. Brand name for gamma-BHC) was used for the first time in fighting the locust. The introduction of BHC marked an important milestone in locust control for although baiting remained unaltered in principle, the substitution of a non-toxic chemical, at normal dosages, for a highly toxic one has allowed bait to be used much more freely without danger to man or livestock. This single fact alone has led to control measures being allowed to take place where once it would have been impossible to operate.

When BHC was first introduced for this work it required a considerable amount of tact and patience on the part of the locust officers to persuade the local tribesmen that BHC bait laid down in areas frequented by their stock would no longer offer any danger of poisoning. There are in fact many instances on record where locust officers have given demonstrations of actually eating bran and BHC bait themselves in an effort to convince these suspicious natives of the safety of the new method of control and it is an extremely difficult and sometimes hazardous business attempting to explain to a tribesman why it is possible for one thing to be killed and yet another should be unaffected when quantities of the same material are consumed. This native opposition to control measures presents a serious problem and although the position is becoming easier each year it is still not unusual for work having to be abandoned in certain areas due to the hostile attitude of the local people.

A standard bait contains 0.5% BHC or approximately 0.065% gamma isomer which, properly applied, can be distributed at 10-lb. per acre (11.2 *kg. per hectare*) and be responsible for killing up to perhaps 5 million hoppers.

In countries covered by Desert Locust Control bait is mixed centrally and then placed at strategic points where it will be readily available in the event of an outbreak. The same bran/BHC ratio is used throughout for control of all instars; it is highly impracticable to have several concentrations in each dump, for taken generally the cost of the actual insecticide contained in the bait amounts to only a very small fraction of the overall cost of the campaign.

## MORE RECENT TRENDS IN CONTROL

Whilst this bran/BHC bait has proved extremely successful in the actual killing of hoppers, one of the major difficulties in the running of an anti-locust campaign is the question of transporting and distributing vast quantities of bait, petrol, oil, spare parts and other items required for day-to-day existence. The territories covered by the D.L.C. organisation are such that good roads are almost non-existent, most of the travelling being through desert areas where very rough tracks offer the only means of passage for wheeled transport.

Means of reducing this transport problem has been in the minds of D.L.C. for some time and, with the recent introduction by Plant Protection Ltd. of a water-miscible formulation of BHC ('Acrodel'), the first opportunity of obtaining cuts in this direction may have been provided. It will be appreciated that the movement of, say, one ton of bait constitutes the movement of  $\frac{1}{2}$  cwt. (25.4 *kg.*) insecticide in the form of 'Agrocode' 7 and  $19\frac{1}{2}$  cwt. (990.6 *kg.*) carrier in the form of bran which, although providing innumerable toxic doses, does entail the shifting of large amounts of non-toxic material. This position cannot, unfortunately, be rectified as really suitable carriers can seldom be obtained locally.

The introduction of water-miscible 'Acrodel' has provided the first chance of having an insecticide that can be moved in its concentrated form and readily diluted locally with water when required. Trials in Eritrea in June 1953 have shown the value of 'Acrodel' as a contact poison; it can be diluted for use against the early instar hoppers to concentrations as low as one part 'Acrodel' to 28 parts water, spraying directly on to the hopper bands. Owing to shifting winds, a complete circuit of each band was found necessary to obtain complete coverage. Up to the present no trial work using water-miscible 'Acrodel' has been carried out against the later instars but there is reason to believe that a concentration in the region of one part insecticide to eight parts water would effect control. The degree to which transport costs could be cut if 'Acrodel' were to be used can be envisaged when it is realised that one cwt. (50.8 *kg.*) of bait

properly distributed will cover approximately 11 acres (4.45 *hectares*) whereas one cwt. (50.8 *kg.*) 'Acrodel,' diluted to an arbitrary figure of, say, one in fourteen, could treat 150 acres (60.75 *hectares*).

Until very recently suitable machinery available for the application of a liquid insecticide was confined to sprayers powered by an auxiliary engine, which naturally involved the driver of the vehicle on which the machine is mounted in a certain amount of wasted time due to stopping and starting his machine. Another disadvantage of this type of machine was that of having a second engine to service and maintain under conditions anything but ideal. The real need, therefore, was for some cheap and simple sprayer powered by the vehicle engine. This need has now been met by Desert Locust Survey themselves, who have developed and produced an exhaust sprayer. This is an extremely simple piece of equipment costing approximately £5 0s. 0d., which relies on the exhaust gases from the vehicle engine to emit a very fine spray. The rate of emission is in the region of 1 quart (1.14 *litres*) per minute and dosage rates per acre may be varied by altering the travelling speed of the truck.

## AERIAL SPRAYING OF FLYING SWARMS

The usual methods of locust control by baiting and spraying are only applicable during the first few weeks of the life cycle. This five-week period constitutes only a small part of the total life of the locust and the need for some method attacking the adult or flying swarms has long been realised.

As long ago as 1934 aircraft were used to attack swarms of red locusts (*Nomadacris septemfasciata* Serv) in flight in Central Africa. Sodium arsenite was the insecticide used and some evidence that locusts had actually been killed was obtained but improvements in equipment, insecticides and tactics were clearly needed. In 1944 aircraft trials were carried out in the Kenya Highlands using a 14% DNC dust. Results were extremely varied but the trials proved useful in providing information on swarm behaviour and other relevant information that was to prove of value in the future. Trials were carried out again in Kenya in 1945 using a 2½% DNC in oil spray and on one occasion a kill of some three million locusts was recorded following the application of 300 gallons (1363.8 *litres*) of spray to a flying swarm. Encouragement was provided to continue further work on these lines.

During 1952 air spray trials, financed by the Colonial Development and Welfare Fund, were resumed. A shortage of swarms hampered the trials but during the second week in February 1952 nearly 900 gallons (4091.4 *litres*) of 20% DNC in oil was applied to four immature swarms. On one occasion a large swarm was continually attacked until it reached such small proportions that it became impossible to see it from the spray plane. It was, however, extremely difficult to find any of the resulting dead locusts for while numbers

could be found on the ground and the shaking of small trees produced a cascade of further dead locusts, the total mortality count was very small in comparison with the original swarm.

On one occasion results were much easier to interpret. During the early evening a small low-flying swarm was seen and attacked with 50 gallons (227.3 *litres*) of oil-soluble 'Acrodel.' Shortly after spraying the swarm settled for the night and practically the entire kill took place over an area of 200 acres (81 *hectares*). These exceptional circumstances made comparatively accurate assessments possible and it was estimated that something in the region of 37,000,000 locusts had been killed. In this aerial spraying experiment the application of 50 gallons (227.3 *litres*) oil-soluble 'Acrodel' resulted in the death of 60—80 tons (61—81.2 *metric tons*) of locusts. Although this seems a striking enough achievement, the M.L.D. (median lethal dose) of *Locusta* spp., as determined by laboratory methods, indicates that the theoretical mortality should be 98.5% greater than the result actually achieved in this field experiment.

It is realised that 100% efficiency will never be obtained as a certain number of spray droplets will always fail to contact locusts, but it is seen that there is plenty of scope to increase the present efficiency ratio.

Aerial spraying of flying swarms naturally dispenses with the aid of ground parties for demarcation purposes and therefore effecting a considerable saving in manpower. Added to this is the work carried out by the Chemical Defence Establishment at Porton, where under controlled conditions it has been found that flying locusts are more susceptible to aerial spraying than settled locusts. At the moment it would appear that aircraft are likely to provide another addition to the weapons ranged against the ever present threat of the locust.



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# THE DEVELOPMENT OF CHEMICAL WEED CONTROL IN MAURITIUS

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THE Island of Mauritius is situated in the South Indian Ocean just within the Tropic of Capricorn, some 1,400 miles (2,253 *km.*) off the East coast of Africa. The area of the island is 720 square miles (1863.7 *sq. km.*) with a population of some 500,000. The main industry is sugar manufacture, the production for 1953 being 512,000 metric tons, a record figure. The cultivated area under sugar cane is about 168,000 acres (68,040 *hectares*).

The country's revenue depends almost entirely on sugar exports and weeding is one of the most important cost items in cane sugar production. It is understandable, therefore, that planters have always sought to lower weeding costs by any possible means. Before the last war weeding was done by hand with the help of a few mechanical weeders over a small area where the soil is free from stones. The area under cane was then about 140,000 acres (56,700 *hectares*) and labour was not as scarce as it is today, but as war progressed, supplying the population with food from overseas became so difficult that the government ordered the planting of food crops over 27.5% of the total area under cane. The land that had to support food crops had in the past always produced cane; regular hand weeding (together with the shade provided by cane leaves after some months' growth) had helped to keep the weeds under control. As food crops provide very little shade to cover the ground, weeds grew profusely and soon the labour was insufficient to keep the fields clean. The situation grew from bad to worse and many of the fields had to be abandoned. When the land reverted to cane cultivation, noxious weeds had become established over an extensive area. Labour was scarce and it was difficult to keep cane fields clean. A weed survey of a large area under cane was started and the data collected proved of immense value when the Sugar Cane Research Station began experiments on the control of weeds with chemicals.

Dr. H. Evans, at that time Botanist of the Research Station, was the first worker in Mauritius to experiment with MCPA and 2,4-D.

The results he obtained were so successful that in one year an area of about 3,000 acres (1,215 *hectares*) was sprayed with MCPA ('Agroxone') to control the noxious weed, *Hydrocotyle bonariensis*. This weed was eradicated from a large area where it grew profusely, even in the shade of fully-grown canes. Estates in which *Hydrocotyle* predominated continued to spray their fields with MCPA. Spraying was done when weeds were one or two inches high. Results were so encouraging that other planters became interested in weed control and many estates began spraying their fields with MCPA sodium salt. Part of the labour was thus released during crop time to carry on the more important work of cutting the canes. Chemical control of weeds gave such encouraging results that today almost every sugar estate includes this practice amongst its vital activities. In 1952 the governing body of the Sugar Industry recommended the use of weed-killers on estates and later the Research Station acquired the services of a Botanist, Mr. E. Rochecouste, who continued the work which had been interrupted by Dr. Evans' departure to another Colony.

Rochecouste laid out carefully planned experiments comparing MCPA sodium salt, 2,4-D esters and 2,4-D amines. A preliminary report was published early in 1953 in which estates were given advice on the correct dosages and modes of applications of various herbicides. An analysis of Rochecouste's experiments shows that the sodium salt of MCPA (as 'Agroxone' 3) has the most lasting effect when used at 3—4 lb. active acid equivalent per acre (3.4—4.5 *kg. per hectare*) on the bare soil, as a pre-emergence application. The 2,4-D esters, used at the rate of 1½ lb. of active acid per acre (1.7 *kg. per hectare*) under the same conditions, have given inferior results in almost all cases. At higher dosages the esters have retarded cane growth to a certain extent. On the other hand 2,4-D esters have given better control of broad-leaved weeds when used as post-emergent applications. In the light of the results obtained, the pre-emergence spraying technique seems to be the best method by which efficient control of broad-leaved and certain graminaceous weeds can be achieved.

### Pre-emergence Spraying

Current weed control practice on sugar estates may be summarised as follows :—

#### (a) *Plant Cane.*

Pre-emergence application of 3—4 lb. of MCPA or 2,4-D active acid in not less than 40 gallons of water per acre (3.4—4.5 *kg. in 4,492 litres per hectare*) just after planting the canes, giving from 6—8 weeks' control of weeds, followed by one or more hand weedings until the cane is strong enough to sustain a second spraying without ill effects. A second spraying, giving further control for 6—8 weeks, allows the cane to form a canopy of leaves that will smother the weeds until harvest.

### (b) *Ratoon Cane.*

Spraying is done on the bare soil in ratoon fields after harvest and after piling the trash on every alternate interline. A hand weeding is performed after 6—8 weeks, fertiliser applied and a second spraying done. The canes should not require weeding until the next harvest.

As stated above it is customary after harvest to pile the trash on each alternate inter-row, leaving the other inter-row bare. Fertilisers are applied in the rows and spraying carried out in the cane rows and in the inter-rows free from trash. At the next harvest the trash is moved on to the inter-rows that remained bare the previous year and the same sequence of work followed. On one estate it was observed after harvesting fields that, while the control of weeds on the sprayed inter-rows was good, weeds grew profusely among the canes in the rows, without being controlled by the weedkiller at its normal rate of application. Hand labour was used to clean the rows with a consequent increase in weeding costs.

On applying the fertilisers under the trash piled on each alternate interline instead of in the rows themselves, and spraying in the normal way, weeds in the rows and interlines free from trash were kept under control for the same period. Consequently this method was adopted on the whole estate after harvesting the fields, the trash covering the same inter-rows for the whole rotation instead of being moved each year. The advantages of this new method are :—

- (a) As the trash remains throughout the crop rotation in the same alternate inter-rows, feeding roots grow profusely among an abundant amount of decaying matter.
- (b) The fertilisers placed under the trash are taken up almost immediately by the numerous feeding roots.
- (c) The fertilisers, being protected by a thick layer of trash, are unlikely to be washed away by the frequent rains prevailing in that region.
- (d) The rows of canes as well as the inter-rows are effectively kept free of weeds by the action of weedkillers ; the weeds not being encouraged to grow by the action of fertilisers.
- (e) Labour is not required to weed the rows and weeding costs have consequently diminished.

The case discussed above shows the importance of practical observations which may considerably help to reduce costs.

### **Post-emergence Spraying**

The same sugar estate experienced great difficulties in controlling broad-leaved weeds and Gramineae by pre-emergence applications,

because, due to almost unceasing rain in that locality, weeds grew very profusely. The obvious method by which to achieve weed control was to spray the young weeds after they had grown above the soil and carry out a post-emergence application. 'Agroxone' 3 alone, when sprayed on established broad-leaved weeds a few inches high, was unable to control them at 3-lb. acid equivalent per acre (3.4 *kg. per hectare*). There was a severe check in growth but weeds soon recovered. That may have been due to the persistent rainfall encouraging growth, or to what has been called the resistance to herbicides of "water-nurtured" weeds. In any case 'Agroxone' alone could not affect the established Gramineae. Therefore, to obtain control of the broad-leaved weeds and Gramineae in one spraying after the weeds had become established, a mixture of sodium chlorate and MCPA sodium salt ('Agroxone' 3) was sprayed at the rate of 2-lb. per acre sodium chlorate plus 3-lb. (2.24 *kg.* + 3.4 *kg. per hectare*) active acid equivalent of MCPA. The weak concentration of sodium chlorate may affect the weeds in such a way as to allow easier diffusion of the hormone weedkiller. This has influenced research work carried out by the Research Institute, where those concerned are trying to find out whether a mixture of one form of 2,4-D or MCPA with sodium chlorate or TCA would provide the answer to most of our weed control problems. TCA gives better results in the control of some grasses than sodium chlorate, and 2,4-D amine gives better control of standing broad-leaved weeds than 'Agroxone' 3; its use is also more economical. Therefore, it is thought that a mixture of 2,4-D amine or MCPA sodium salts and TCA should in future meet nearly all requirements as regards control of weeds in sugar cane fields.

Esters have also been used to control broad-leaved weeds. On standing weeds esters are even more toxic than amines and give very good control but unfortunately, owing to a check in cane growth being observed after their regular use, they are now very seldom applied. Although very effective weedkillers they should be used with great care in order to avoid damage to canes.

### **Spraying Machinery**

The picture would be incomplete if nothing was said concerning sprayers :—

The first that were used to apply weedkillers were Knapsack types worked by a hand lever attachment. These machines were later displaced by pneumatic type Knapsack sprayers in which air and liquid are forced into the container by means of a powerful pump. During the last two years the use of this type of sprayer has spread to all the estates. But some months ago a new and improved version of the first type of hand-operated Knapsack sprayer was introduced and the machine has been found to be efficient. Generally the choice of sprayers has been left to the buyer's fancy. No research has yet been

carried out on the best type of machine to use, the pressures at which to spray, the method of filling the machines rapidly so that each sprayer works to full capacity, etc. One of the most important questions to be considered in the use of herbicides is the right type of machine for the right job. The nozzles are also of great importance and there is certainly much research needed on the type and density of spray as well as particle size produced by nozzles of different sizes.

There is no doubt that weed control by chemicals is still in its early stages in Mauritius. Nevertheless much has been achieved in recent years. With a reorganised Research Station and the acceptance by planters of the necessity of using weedkillers, we are certain that in a few years we shall have a fixed programme of weed control by chemicals in sugar cane that will meet all our requirements.

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# TECHNICAL BREVITIES

*This section includes information on plant protection problems obtained from published literature. We give references to the publications concerned.*

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## INSECTICIDES

### BENEFITS FROM INSECTICIDES IN U.S.A.

IN an article in *Agricultural Chemicals*, Vol. 9, No. 2, 1954, Dr. G. C. Decker emphasises the value of insecticides in crop protection in the U.S.A. and gives interesting comparative yields of crops before and after the introduction of DDT. For example, the following yield increases apply to crops which were also extensively treated with chemicals before DDT came into general use in 1946:—cotton, 6.74%; cabbages, 11.88%; celery, 40.74%; potatoes, 61.75%; sugar-beet, 74.28%.

### ARMY WORM CONTROL

E. J. Martyn and N. M. Hudson state, in the *Tasmanian Journal of Agriculture*, Vol. 24, No. 4, that the army worm, *Persectania ewingii*, causes sporadic damage to cereal, grass and leguminous crops in Tasmania, and that it can be effectively suppressed by low volume spraying with DDT (4 oz. actual DDT per acre) (0.3 kg. per hectare) or by dusting DDT 5% at 8-lb. per acre (9 kg. per hectare).

### TURNIP GALL WEEVIL ON CABBAGE

In *Plant Pathology*, Vol. 2, No. 4, pp. 123—125, 1953, it is recorded that cabbages are most effectively protected against turnip gall-weevil, *Ceuthorrhynchus pleurostigma*, by dusting seedbeds four weeks after sowing, when second pair of rough leaves are formed, with 2% technical BHC dust (0.26% gamma isomer). Application of the dust around the bases of transplanted plants at the rate of 1-lb. (0.45 kg.) per 160 plants also provides good protection against the pest. DDT 5% dust was found to be inferior. All insecticides tested gave better protection to spring cabbage than to the winter crop.

### TREATMENT OF TOBACCO PLANTINGS AGAINST WIREWORM

According to J. A. Begg, in the *Report of the Entomological Society of Ontario* for 1952, Vol. 83, pp. 54 to 57, published in 1953, tobacco is

effectively protected against the eastern field wireworm, *Limonius agonus*, by lindane. Field trials over three years have shown that best results are obtained when lindane is applied in the planting water at the rate of 1 oz. of 25% wettable powder per 40 gallons (16 gm. per 100 litres). Although the percentage of infested plants may be reduced from 22 to 5 the reduction in wireworm population has never been greater than 25%. Annual treatment is, therefore, necessary and seed treatment of the alternate crop (rye) is also advisable. Increased growth is recorded. Aldrin, parathion, heptachlor and chlordane were inferior to lindane, chlordane showing some phytotoxicity.

### **TREATMENT AGAINST LUCERNE FLEA**

M. M. H. Wallace records in the *Australian Journal of Agricultural Research*, Vol. 5. No. 1., pp. 148—155, 1954, that pasture top-dressing with crude BHC, 0.5%, at the rate of 1 cwt. per acre in superphosphate (125.4 kg. per hectare) is effective against the lucerne "flea," *Sminthurus (Sminthurus) viridis*. Initial trials with 50% BHC dispersible powder, at the rate of 2-lb. per acre (2.24 kg. per hectare), are also promising. DDT not only gives poorer kills, but it also eliminates predator bdellid mites.

### **CLOVER SEED WEEVIL**

According to W. E. Heming in the *Report of the Entomological Society of Ontario* for 1952, Vol. 83, pp. 59—65, published in 1953, excellent treatment against the clover seed weevil, *Miccotrogus (Tychius) picirostris*, consists of the application of soil insecticides after harvest, when all stages of the insect, except eggs, are present in the surface soil. Good field kills are given by the following treatments, in lb. per acre:—lindane wettable powder, 0.25; aldrin, 1.5; dieldrin, 1.5; heptachlor, 1.75 (0.3 kg., 1.7 kg., 1.7 kg., 2 kg. per hectare). Cultural methods are also of value.

### **TOMATO FLEA-BEETLE**

J. E. Armand, in the *Report of the Entomological Society of Ontario* for 1952, Vol. 83, pp. 58—59, published in 1953, suggests spraying with DDT as a routine measure for the suppression of tomato flea-beetles, of which *Epitrix cucumeris* is the most common. The insecticide can be conveniently combined with the last fungicidal spray before planting out. DDT 50% wettable powder, 1 oz. to 2½ gallons of water (+1 oz. thiram) (250 gm. DDT+250 gm. thiram per 100 litres) reduced injury by 72% and yields were increased from 6.39 to 8.97 tons per acre (16.1 to 22.4 metric tons per hectare). This increase, valued at \$90.00., compares with an expenditure of 25 cents per acre. Protection against cutworms is also obtained.

### **EFFECT OF DEFOLIANTS ON COTTON PESTS**

R. C. Gaines, B.E.P.Q., stated in a speech at the Annual Louisiana Insect Control Conference, published in *Agric. Chem*: Vol. 9, No. 2, p. 73, 1954, that boll weevils leave chemically defoliated cotton and hibernate in poor condition. The speaker also suggested that all leaf-feeding insects would be eliminated.

## CITRUS WHITEFLY

A. Targe and L. Deportes report in *Phytoma*, Vol. 44, pp. 9—15, 1953, that citrus whitefly, *Dialeuiodes citri*, has become a serious menace to fruit trees, especially the orange, and certain ornamentals in the French Maritime Alps. The damage is done by the larvae, which fix themselves mainly to the undersurfaces of leaves and produce honeydew, which covers the foliage and asphyxiates the plants. The pest hibernates as larvae and adults appear at the end of April, hatching of the first generation starting a month later. There are three generations and a partial fourth in the season. Adult treatments are unsatisfactory and costly. White oil, with or without DDT or parathion, has little or no effect against eggs, but larvae are almost completely destroyed by spraying with white oil, 1.5%. The best time for treatment is at the end of June or the beginning of July when larvae of the first generation are hatching. Treatment in the third week of October against the final generation would also be very satisfactory.

## APPLE LEAF-HOPPER

It is stated in the *Agricultural Gazette of New South Wales*, Vol. 64, No. 4, pp. 219—220, 1953, that the apple leaf-hopper, *Typhlocyba froggatti*, is now a pest only in districts where lead arsenate is still used for codling moth control. It is well controlled by DDT, 0.1%, sprayed early in the season before winged forms occur, but the Department of Agriculture recommend the use of nicotine sulphate if later control is necessary.

## TREATMENT OF CUCURBIT PESTS : EFFICIENCY OF GAMMA-BHC AND ZINEB

W. J. Reid and F. P. Cuthbert report in a publication of the U.S. Bureau of Entomology, E-856, 1953, results of trials from 1948 to 1951 for the suppression of the pickleworm (*Diaphania nitidalis*), melonworm (*D. hyalinata*), melon aphid (*Aphis gossypii*) and other insects attacking cucumbers and squash. Lindane was the most effective material given extensive trial. It resulted in excellent suppression of all insects present on these crops either as a 1% dust applied weekly at about 20-lb. per acre (22.4 kg. per hectare) or as a spray at comparable dosage. Slight off flavour may result from the use of lindane during the fruiting period, though this would probably not be noticed by the average person, and lindane has been extensively used by commercial growers without complaints of taint. Potatoes following cucumbers may be affected. Although the use of BHC was abandoned owing to phytotoxicity, lindane at the above rates does not injure but a 1% dust every five days sometimes caused slight to moderate damage. Zineb gives partial control of the pickleworm and its use as a fungicide at 1.3-lb. per 100 gallons (130 gm. per 100 litres) and 40 to 80 gallons per acre (449.2 to 898.4 litres per hectare) makes it possible to reduce the dosage of lindane, e.g. excellent protection of cucumbers was obtained by five applications of 0.5%

lindane dust accompanied by weekly spraying with zineb. Parathion, aldrin, dieldrin and endrin showed considerable promise, but many common insecticides were less satisfactory.

### DESERT LOCUST CAMPAIGN IN TURKEY

According to S. Erkilic in *Tomurcuk*, Vol. 2, No. 22, pp. 16—18, 1953, the 1953 campaign against the desert locust in Turkey was so successful that not even a single hopper remained. BHC was used throughout, nearly all as 'Agrocide' 7 (2.6% gamma-BHC) applied against mature and settled swarms as dry baits consisting of 5 kg. 'Agrocide' 7 to 100 kg. wheat bran at 40 kg. per hectare (5-lb. to 100-lb. at 35½-lb. per acre), or as moistened baits of 6 kg. 'Agrocide' 7 to 100 kg. bran plus 40 litres of water (13¼-lb. to 220½-lb. plus 8¾ gallons) at 50 to 60 kg. per hectare (44½-lb. to 53½-lb. per acre). Against hoppers, use was made of a dry bait of 3 kg. to 100 kg. bran (6½-lb. to 220½-lb.) at 40 to 50 kg. per hectare (35½-lb. to 44½-lb. per acre). Over 5,700 tons (5,791.2 metric tons) of adults and hoppers were killed by about 41 tons (41.7 metric tons) of chemicals.

### TREATMENT OF WHITE GRUB: INSECTICIDE PERSISTENCY IN SOIL

J. B. Polivka writes in *J. Econ. Ent.*, Vol. 46, No. 3, pp. 517—519, 1953, that studies in the persistency of insecticides applied to the soil for control of larvae of the Japanese beetle, *Popillia japonica*, in Ohio show that BHC at 2.5 to 5.0-lb. per acre (2.8 to 5.6 kg. per hectare) gave good protection against grubs and had a good residual effect over 6 generations and at 10-lb. per acre (11.2 kg. per hectare) for 7 generations. Toxaphene at 5-lb. per acre (5.6 kg. per hectare) showed a significant reduction for 3 generations and at 25-lb. per acre (28 kg. per hectare) and more for 6 generations. Parathion at 1 to 25-lb. per acre (1.1 kg. to 28 kg. per hectare) had some persistency over 1 to 4 generations. Methoxychlor, which was less effective in control, lost effectiveness at rates over 25-lb. per acre (28 kg. per hectare) after 6 generations.

### TREATMENT AGAINST SAWFLY

M. Sekic records in *Plant Prot.* (Belgrade), No. 18, pp. 18-48, 1953, that studies in the biology of *Hoplocampa* spp. (mainly apple sawfly, *H. testudinea*; pear sawfly, *H. brevis*; and plum sawfly, *H. flava*), emphasise the need for accurate timing of insecticides. For plum-tree treatment, DDT emulsions gave complete control if applied when 75% of the flowers had been fertilised, i.e. immediately after the hatching of the larvae. Because this is the moment when secretion of nectar is stopped, bees are not harmed, but wasps which are still laying their eggs are destroyed. Results with DDT on pome fruits were less effective, for the larvae immediately on hatching go directly from the chorions into the fruit and the DDT preparations had no penetrating effect. Parathion, however, applied (as 'Fosferno' and other formulations) to *Prunus* and *Pyrus* at the end of the incubation period acted mainly on larvae in chorions owing to its penetrating effect and there was no damage to plum, apple or pear fruit. On apple trees small larvae entering fruit were killed immediately.

## TREATMENT AGAINST CHERRY FRUIT FLY : SYSTEMIC ACTION IN FRUIT

K. E. Frick and H. G. Simkover record in the *Journal of Economic Entomology*, Vol. 46, No. 2, pp. 361-362, 1953, that in Washington larvae of the cherry fruit fly, *Rhagoletis cingulata*, were killed within cherries by a post-harvest spraying with parathion, 25% wettable powder, at 1-lb. per 100 gallons (100 gm. per 100 litres), or 'Systox,' 32.1% emulsifiable liquid, at 1 pt. per 100 gallons (125 c.c. per 100 litres). Best kills were apparent five days after spraying in early August. As many cherries without visible breathing holes contained dead larvae as those with such holes.

## CURRENT BORER

According to E. F. Taschenburg in the *Journal of Economic Entomology*, Vol. 46, No. 3, pp. 394-400, 1953, very effective treatment against the currant borer, *Ramosia (Aegeria) tipuliformis*, is provided by one application 10 to 14 days after the first moths emerge, of 0.5% parathion wettable powder at 1.5-lb. per 100 gallons (150 gm. per 100 litres). Action is against the eggs, not larvae in the canes. Other organic phosphates, including malathion, and DDT and DDD, were less effective.

## FUNGICIDES

### TREATMENT OF VEGETABLE LEAF DISEASES

It is stated in the *Rep. Dep. Agric.*, Malaya for 1952, published in 1953, that weekly spraying with 'Perenox', 0.25%, effectively protects carrots and French beans against leaf diseases. 'Perenox', 0.5%, is required for successful treatment of celery leaf spot (*Septoria apii-graveolentis*) and potato blight (*Phytophthora infestans*). 'Perenox', 0.25%, reduced infestations of leaf blight (*Helminthosporium turcicum*) and rust (*Puccinia sorghi*) on maize but severely scorched the leaves.

### RED RUST OF TEA

In the Report of the Indian Tea Association Scientific Department for 1952, published in 1953, G. M. Das and K. C. Sarmah state that winter spraying of tea with 'Perenox', 0.5%, plus 'Ovicide', 5%, with or without an April treatment of 'Perenox', 0.5%, plus 'Ovicide', 1%, delayed the development of fructification of the alga, *Cephaleuros parasitica*, cause of red rust. Winter sprays of 'Perenox', 0.5%, plus tar oil, 5%, of lime wash and of caustic soda, with or without lime, were of little value.

### APPLE AND PEAR SCAB

H. Darpoux writes in *Phytoma*, Vol. 46, pp. 11-15, 1953, that trial spray programmes in France against apple and pear scab (caused by *Venturia inaequalis* and *V. pirina* respectively) have shown the

superiority of captan, 0.5%, giving 94% of first-grade fruits. Good results, marred by some russetting, were also given by a programme of copper oxychloride, 0.5% (apples) or 0.25% (pears), before bud-burst, followed by two sprays of ferbam, 0.25%, and one of sulphur.

## PEACH BROWN ROT

In *Phytopathology*, Vol. 43, No. 5, p. 290, 1953, H. H. Foster reports that wettable sulphur at 6-lb. per 100 gallons (600 *gram.* per 100 *litres*) was the best treatment of peaches against the brown rot fungus, *Monilinia* (*Sclerotinia*) *fructicola*, out of five fungicides tested. Eight sprays were made, starting from petal-fall.

## TREATMENT OF STRAWBERRY MOULD

Dr. Powell reports in *Phytopathology*, Vol. 43, No. 9, p. 482, 1953, that four treatments with 50% captan at 6-lb. per acre (6.7 *kg.* per *hectare*) at weekly intervals are promising against strawberry mould, *Botrytis cinerea* (*Sclerotinia fuckeliana*). Dissemination of the mould is so rapid, however, that the treatment has unsatisfactory results when untreated patches exist in a treated area.

## TREATMENT OF CONIFER SEEDLING DISEASES

According to R. S. Cox in *Phytopathology*, Vol. 43, No. 9, p. 469, 1953, a disease complex consisting of damping off, root rot, stem canker and needle blight, with *Cylindrocladium scoparium* as the primary organism, results in losses of from 75% to 100% in white pine and Douglas fir seedlings. An effective treatment consists of a combination of soil fumigation and foliage sprays. Soil fumigation before sowing is accomplished with formaldehyde (1:25 concentration, 1 quart per square foot) (12.2 *litres* per *sq. m.*) or chloropicrin (1 gallon per 1,000 square feet) (489.2 *litres* per *hectare*). The following materials are advocated to suppress the stem and foliage symptoms, sprayed monthly from May to September:— Bordeaux mixture, 8:8:100, (0.8% Copper Sulphate), manzate (1½-lb. per 100 gallons) (150 *gram.* per 100 *litres*), zineb (2-lb. per 100 gallons) (200 *gram.* per 100 *litres*), ferbam (2-lb. per 100 gallons) (200 *gram.* per 100 *litres*), thiram (1½-lb. per 100 gallons) (150 *gram.* per 100 *litres*).

## TREATMENT OF DAMPING-OFF IN CONIFEROUS SEEDLINGS: PELLETTED SEED

J. G. Berbee and others write in *Phytopathology*, Vol. 43, No. 9, p. 466, 1953, that tests with 28 fungicides during three years in Wisconsin have shown that pelleting the seed in 50% thiram with 4% methyl cellulose as a sticker is the best treatment against damping-off in coniferous seedlings, caused mainly by *Pythium irregulare* and *Rhizoctonia solani*. A rate of 8 oz. thiram and 3 oz. methylcellulose per lb. of seed (448 *gram.* and 168 *gram.* per *kg.*), and even 2 oz. thiram per lb. (112 *gram.* per *kg.*) in spring seedlings, was sufficient, but rates of up to 4-lb. per lb. (4 *kg.* per *kg.*) have caused no seedling injury. Soil applications were less effective.

## APPENDIX

The following chemicals mentioned in this issue are available in the 'Plant Protection' range of products under the trade names given below :—

### Lindane

'Gammalin' Liquid Concentrate, containing 10% gamma BHC.

'Gammalin' 20, containing 20% gamma BHC.

### BHC (Benzene Hexachloride) :—

'Agrocide' insecticides, containing 2.6%, 6.5%, 10% or 13% BHC.

### DDT

'Didimac' insecticides, containing 25% or 50% DDT.

### Parathion

'Fosferno' insecticides, containing 20% or 50% parathion.

### White-oil

'Abolineum' ('Alboleum').

### Thiram

'Fernide', fungicidal spray.

'Fernasan' A, seed dressing.

### Wettable sulphur

'Spersul.'

### Copper Spray

'Perenox.'

### 2,4-D

'Fernoxone', containing 80% sodium salt of 2,4-D.

'Fernimine', containing 2,4-D as an amine salt.

'Fernesta', containing the butyl ester of 2,4-D equivalent to approximately 6-lb. acid per Imperial gallon.

### MCPA

'Agroxone' 4, based on the potassium salt of MCPA, and containing approximately 4-lb. acid equivalent per Imperial gallon.

### Organo-mercurial compounds

'Agrosan' GN and GN5—seed dressings, containing organo-mercurial salts equivalent to 1% or 5% mercury.



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